CAN MANY "LITTLES" MAKE A "MUCH"? ONE APPROACH FOR TRANSFORMING UNDERSPECIFIED THEORY INTO AGENCY-ORIENTED RULES AND BEHAVIORS

D. SAUNDERS-NEWTON,* L. ROSZMAN, and A. FRANK,
BAE Systems AIT, Arlington, VA
R. AXTELL, The Brookings Institution, Washington, DC

ABSTRACT

While models of social agents and complexity are powerful tools for understanding societal phenomenon, appropriate and credible observation and interpretation of model output requires the lens of theory. Unfortunately, many compelling theories of social structure and dynamics are not specified in a fashion that allows for their easy instantiation as agent-based models. This paper describes some of the challenges faced by one team of researchers as they attempted to exploit the insights inherent in cultural evolution theory by converting an agent-based model of social formation, fragility, and dissolution.

Keywords: Social complexity, cultural evolution, agent-based modeling, societal fragility

INTRODUCTION

Models of social agents and complexity are powerful tools for thinking about societal phenomenon. By eschewing modeling norms such as extreme reductionism and aggressive parsimony, social scientists and inquirers can consider social structure and dynamics in a fundamentally different fashion that links micro and macro levels of observation. However, this methodological approach must confront a number of nontrivial challenges. Of particular interest to the authors is the transformation of grand theories on the evolution of social complexity (e.g., the frameworks of cultural evolution and collapse as expressed by Kent Flannery or Joseph Tainter) into an agent-based model (ABM). These grand theories are typically underspecified in terms of agency. Thus, it is important to consider a scheme for transforming theory pertaining to aggregate (global-level) features of society and culture into an agency-based (local-level) formalism.

The grand theory underlying this research effort focuses on the notion that states — particularly nation-states — emerge from increasing levels of socio-political/socio-physical complexity. This conceptual frame emphasizes the belief that a transition within and across the hierarchy of a society either toward increased complexity (e.g., the transition from "chiefdom" to a nation-state) or away from a complex form such as the nation-state is an anticipated and likely transformation. While scholars can question whether the aforementioned evolutionary imperative is a "truth," theories of evolving social complexity provide a compelling description of social

* *Corresponding author address*: Desmond Saunders-Newton, BAE Systems Advanced Information Technologies, 3811 North Fairfax Drive, Suite 500, Arlington, VA 22203; e-mail: desmond.saunders-newton@baesystems.com.

transformations with historical and contemporary significance. While the aforementioned framework of cultural evolution is compelling because it is grounded in general systems theory, it is difficult to instantiate as an agent-based formalism. What was necessary was a translation of the high-level dynamics of such cultural/civilization evolutionary theories into the language of micro-motivated agents (i.e., theories of individual choice, obligation, and opinion formation).

This paper describes the approach pursued by the authors to instantiate a grand theory of social/cultural transformation in order to better understand nation-state structure and dynamics. To that end, the paper presents a general overview of the motivation for modeling state formation, fragility, and dissolution (failure). This overview is followed by a description of the specific model formalism forwarded in this modeling effort, as well as the underlying ABM instantiation. The authors conclude this paper with general lessons for translating global-level theory into agency-level rules, routines, and dynamics.

OVERVIEW: THE NECESSITY OF MODELING THE STATE

The particular problem motivating the creation of this particular model was that of political instability and state failure. While such terms have multiple meanings, the general consensus among applied researchers concerned with supporting defense planners and strategic analysts clustered around the collapse of legitimacy on the part of the central government and the emergence of armed regional- or national-level rivals to centralized authority.[1] While the result of state failure is the loss of territorial sovereignty and the monopolization of the means of violence, such outcomes can be the result of multiple complex processes that include economic, environmental, cultural, geopolitical, technological, demographic, and other forces. This particular effort started as a Defense Advanced Research Projects Agency (DARPA)-funded exploratory effort called PCAS,[2] and was extended with internal research and development funds.

DARPA's venture into state failure as a research area marks an important turning point in defense and security policy. Traditionally, the U.S. Department of Defense (DoD) has focused its resources on deterring and defeating strong states — nuclear and conventional military forces that directly threatened U.S. citizens, territory, and allies. While the threat posed by nuclear and conventional military forces remains, other nontraditional threats have increased in quantity and quality. Irregular warfare in the form of insurgent movements, international terrorism, and the proliferation of weapons of mass destruction (WMD) has become a growing threat (Snow 2004). Moreover, most of these threats do not emanate from the traditional sources of ideologically opposed strong states; rather, they arise from discontented segments of societies residing in states that are too weak to control their populations. Thus, as states weaken and fail, their populations may challenge the legitimacy of central government and engage in hostile attacks against targets within and without the country.

Developing technology to support the analysis of state failure and political stability is new neither to the military nor the security community in general. In the mid-1960s, the

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1 Other challenges to legitimacy included how precursor events, such as pandemics or natural disasters, could result in a loss of sovereignty or governance capacity.

2 Pre-conflict anticipation and management "seedling/sapling" effort; AFRL Contract (FA-8650-05-C-7243).

U.S. Army conducted a major social science research program on insurgency that covered a range of methods, including ethnographic field research, statistics, and computational modeling. Although this program was quickly cancelled for policy and methodological reasons, its initiation demonstrated a long-standing belief in the value of social science research to the defense community that had developed out of the use of behavioral and communications sciences during World War II (Bray 1962; de Sola Pool 1963; Horowitz 1974; Knorr 1964; Deitchman 1976). Likewise, other organizations within the defense and international security community have also sought to develop technologies to support the assessment of political stability and prevent state failure. These efforts ran the gamut from the design and development of dynamic and statistical models, to systems for indications and warning, to virtual collaborative environments for coalition building and planning preventive actions; examples include the Carnegie Commission on Preventing Deadly Conflict, the Political Instability Task Force, the Conflict Early Warning Systems, and the Pre-Conflict Management Tools Program (Carnegie Commission 2005; Alker et al. 2001; Frank 2005). Indeed, political assessment and the attempt to identify and intervene in weak and failing states before a crisis occurs were priorities for the DoD even before 9/11 demonstrated the linkages between state failure and international terrorism (Rumsfeld 2001).

STATE FORMATION AS SOCIAL COMPLEXIFICATION

As noted earlier, this particular research was concerned with identifying instances of state fragility, failure, or dissolution. In support of this state fragility/failure modeling effort, the authors developed an ABM that exploited the theories pertaining to the evolution and collapse of social complexity. This model was named SOET (i.e., Societies, Organizations, Elites, and Territories) on the basis of the notion that states are societies composed of elites who manage information and formal organizations over specified territorial bounds.

The authors developed a model of state failure based on a bottom-up process of state formation and societal fragility — processes of increasing and decreasing levels of social complexity. This theoretical process was instantiated as an ABM, a methodology particularly well suited for exploring the dynamics of decentralized, distributed systems, such as the formation or dissolution of states based on individual and institutional decision making. This approach adopted a theoretical frame of increasing and decreasing social complexity grounded in the anthropological literature on state formation and societal collapse. This theoretical framework was selected for several reasons — most important of which was its ability to provide insights into the dynamics of state failure and provide an institutional model of state health.

It is worth noting that the dynamics of state failure remain relatively unexplored formally; indeed, the dynamics of political systems remain underrepresented in within social science research when compared to comparative and cross-sectional perspectives (Pierson 2004). While there exists a general consensus that states fail and governments collapse as a result of a process that unfolds over time, little consensus exists on how fast these processes occur, the sequencing of events within the processes, or the kinds of warning that decision makers may be able to acquire in order to organize successful interventions. For example, numerous studies of revolutions, social movements, and societal collapse note the importance of political, intellectual, and ideological elites; however, the times at which they enter the process and the particular effects that they have on the process of state failure vary (Arendt 1965; Brinton 1965; Tainter 1988; Skocpol 1997; Goldstone 2003; Tilly 2004).

Alternatively, a large body of work is focused on the empirical indicators of state failure, and massive collections of statistical data have focused on the search for correlations or variables that differentiate stable from unstable states. These studies include the Correlates of War research project, the Political Instability Task Force, the Carnegie Commission on Preventing Deadly Violence, and others. These efforts are largely statistical and, while differing in their details, generally classify states in similar broad ranges of stability based on available empirical data and political, economic, and social indexes.[3]

Even though statistical and empirical work on state failure has largely converged on a core set of indicators of state failure, several unexplained dynamical factors have yet to be appropriately addressed. Moreover, definitional and theoretical clarity has yet to be achieved, causing researchers to question the fidelity of their findings; states may have multiple paths to failure, and these different paths have yet to be adequately explored or modeled (King and Zeng 2001).

Given that most of the models in the area of state failure have emphasized the search for statistical patterns, our research team decided to focus on the dynamics of state formation and failure in order gain better insights into the processes by which populations come together under stable political authority and which lead to a collapse of that authority.

Theoretical Foundation: Cultural Evolution

This research effort adopted a definition of state failure that was grounded in anthropological theories of the state and social complexity.[4] This disciplinary foundation was significant, because it regards the state as a functional construct possessing particular institutional properties. Thus, the BAE Systems' model sought to differentiate between societies that are organized into states and those that are organized into other social and political structures such as tribes and chiefdoms.

The primary theoretical frame of the BAE Systems' model was based on Kent Flannery's anthropological research on the evolution of social complexity. Flannery's model describes how changes in social complexity, as measured through evolving social institutions, occur over time and transition from bands to tribes to chiefdoms to states (Flannery 1972, pages 399–426). Flannery's theory was selected for two reasons. The first reason was the deficiencies of output models of state failure that dominate the study of state failure within political science. The second reason was that Flannery's model has been difficult to instantiate formally on the basis of

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3 For a sampling of statistical investigations into state failure and societal fragility, and associated indexes see *The Correlates of War*, available at http://www.correlatesofwar.org, accessed on September 12, 2005; *The Carnegie Commission on Preventing Deadly Conflict*, available at http://www.wilsoncenter.org/subsites/ccpdc/index.htm, accessed on September 11, 2005; *Political Instability Task Force*, available at http://www.cidcm.umd.edu/inscr/stfail, accessed on September 11, 2005; *Polity IV Project*, available at http://www.cidcm.umd.edu/inscr/polity, accessed on September 12, 2005; and *Freedom House*, available at http://www.freedomhouse.org, accessed on September 12, 2005.

4 It is important to note that the term "social complexity" is not used to imply whether a society is sophisticated, nor to speak to the qualities of the individuals living within it. The term discusses the particular institutional organization and practices of a society as they work to achieve collective ends such as food production, distribution of wealth, economic management, the enforcement of social norms and political laws, etc.

mainstream quantitative methods; thus, instantiating it computationally would constitute a significant methodological development, demonstrating the unique abilities of computational social science methods.

Most models of state failure focus on whether the state delivers a given set of services to its citizens (i.e., they emphasize its outputs). Indeed, one leading scholar in the area of state failure notes, "It is according to their performances — according to the levels of their effective delivery of the most crucial political goods — that strong states may be distinguished from weak ones, and weak states from failed or collapsed ones" (Rotberg 2004). Likewise, another leading scholar argues, "Why do states collapse? Because they can no longer perform the functions required for them to pass as states" (Zartman 1995, page 5). While this approach is effective in making normative assessments, it ultimately suggests that states fail as a result of their internal weakness or their policy decisions. Thus, even strong states, such as Nazi Germany or Stalinist Russia, which did not support free markets or protect individual rights, would be classified as weak or failed because they adopted policies that ran counter to the preferences of liberal democracies.[5]

Output-based models of state failure experience several logical difficulties. As a result, these models produce a confusing array of inconsistent and incompatible results. For example, output models differentiate between weak, failed, and collapsed states, and note that failed states are weak while weak states may not have failed and may not fail in the future (Rotberg 2004, pages 1–25). Likewise, states that experience genocide or politicide are regarded as having failed.[6] Yet, the organizational complexity and discipline required to commit these acts are high. Thus, strong states that pursue policies of genocide or politicide are regarded as having failed, despite the fact that they are organizationally and ideologically sophisticated enough to mobilize efficient, yet horrific, campaigns against targeted groups (Kavka 1986; Smith 2005a). The conclusion is that the state has not failed because it is weak, but because it pursues political ends that run counter to the normative standards of contemporary liberal democracies.

Given the deficiencies of output models of state failure, the authors sought to create a model that provided an empirical and operationalizable definition of the state and is therefore less subject to claims and interpretations of state stability based on normative or contextualized nuance. As a result, the research team turned to the notion of social complexity more commonly represented in anthropology. Studies of social complexity emphasize the internal structure of societies rather than their outputs. Societies are categorized broadly into bands, tribes, chiefdoms, and states — where each category has particular organizational properties. According to Flannery, the features of each level of social complexity are as follows:

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5 It is important to note that while Nazi Germany eventually collapsed, it took the combined military and economic effort of the world's great powers to defeat it. Likewise, Stalinist Russia eventually succumbed to the internal weaknesses identified in 1947, but this process took four decades to complete and bifurcated the world militarily, economically, and politically in the form of a Cold War. In both cases, authoritarian states displayed significant organizational and technological capabilities that discredit any notion that these were weak states based on their ideology or policy choices. For an assessment of the internal problems of Stalinist Russia, see George F. Kennan, writing as X (Kennan 1947).

6 State Failure Task Force, *Phase III Findings*, available at http://www.cidcm.umd.edu/inscr/stfail/SFTF%20Phase%20III%20Report%20Final.pdf, accessed on September 15, 2005.

- *Bands.* These are simple egalitarian societies that are segmented along lines of kinship and marriage. Leadership within bands is limited and ephemeral, and the division of labor is based on age and sex. Ceremonies, whether religious or political, are ad hoc, and occur only when sufficient time and people are available. Bands are most commonly found among hunters and gatherers and are regarded as the dominant form of social order prior to 10000 BCE.

- *Tribes.* These are relatively large egalitarian societies whose membership extends beyond lines of kinship. Leadership in tribes is weak and largely based on personality and individual loyalty. Ceremonies are conducted on a schedule, occurring regularly on a "calendric" basis. Tribes maintain a weak sense of property rights, as land and property are owned within familial structures. The first tribes are believed to have emerged in 7000 BCE.

- *Chiefdoms.* Chiefdoms are larger than tribes and display inegalitarian distributions of, and access to, resources. Social status is hereditary, and land and property transfer from one generation to another within the family. Social stratification allows for the emergence of an elite class that manages official social rituals, and the position of the chief is institutionalized — it exists regardless of the individual who occupies it. However, while the chief occupies a settled office, the administration is filled by people who are personally loyal to the chief. The first chiefdom is believed to have emerged in 5500 BCE.

- *States.* States are highly stratified societies with institutionalized bureaucracies, and landownership and property rights. States possess strong centralized governments, and the bureaucracy is occupied by a professional class that is divorced from bonds of kinship. States maintain a near monopoly over the means of violence, and elites have advantageous access to resources. A small percentage of the population of states is involved in the production of food, while others perform specialized crafts and services (Flannery 1972, pages 401–404).

Although anthropologists have contested the precise meaning of these terms, noting that societies categorized in one way have often displayed features of higher or lower stages of complexity, the community has nevertheless accepted the general contours of a scale of social complexity based on the internal organization of the society (Tainter 1988, pages 28–31; Blanton et al. 1993, pages 10–19).

The implications for distinguishing between states and other social organizations are important. Leading theories of warfare emphasize the manipulation of adversary social and physical networks and the isolation and removal of enemy leadership (Frank 2004). Understanding the level of social complexity within a society enables the analysis of leadership structures and the underlying social structures; these structures will respond differently based on the isolation or removal of their leadership, and the leadership will respond differently to economic, military, and environmental crises. Indeed, the difficulties encountered by the U.S. military in Iraq reveal the complexities of manipulating societal structures through the use of force and the removal of the leadership. By assuming that Iraq's internal organization was that of a state, military planners concluded that its governing and economic institutions could

continue to operate despite the removal of individuals loyal to Saddam Hussein and the Bath Party (Bodansky 2004; Mann 2004). However, by viewing Saddam Hussein's Iraq as a chiefdom lacking an institutionalized, professional bureaucracy, and managed on the grounds of political and personal loyalty, the expected effects of the leadership's isolation and removal become quite different.[7] Indeed, the individual chief, or what other anthropologists have referred to as the "Big Man," is so dominant that his removal, and the removal of those aligned with him, creates a power vacuum and causes the society to collapse into smaller, less complex social units, such as bands, tribes, and smaller chiefdoms (Tainter 1988, pages 25, 38).

On the basis of anthropological models of social complexity, BAE Systems developed a model that examines the process by which societies transition into and out of states. Thus, Flannery's theory produces a bi-directional process in which societies increase and decrease in social complexity. State formation is the process by which societies develop institutionalized, hierarchal organizations of political, economic, and military management, while state failure is the loss of these attributes.

Underspecification and Theoretical Adaptation

Given the nature of Flannery's theory, and the limitations of traditional modeling formalisms, formally testing Flannery's evolutionary ideas has been difficult even though it has served as a leading theory of societal evolution for more than three decades (Owen 2005). To instantiate Flannery's ideas on changes in social complexity into a computational model capable of exploring social dynamics and producing outcomes with enough specificity as to be testable and useful within the context of the DARPA effort, Flannery's theoretical scheme was expanded. This expansion was necessary to formalize behavioral properties of individuals and organizations into algorithms. Once in algorithmic form, these behaviors were used to populate an ABM discussed in detail later.

From a formal perspective, model underspecification occurs when the model identifies more variables than it possesses rules for — whether those rules are mathematical equations or behavioral/procedural algorithms. Flannery's theory provides a description of the dynamic that produces increases in social complexity, but it does not explicitly delineate behavioral rules for the organizations and individuals that compose the society. Therefore, while it is known that individuals and organizations interact in ways that dynamically alter the social structures in which they reside, the specific causal path between individual action and societal outcome is not specified by Flannery. To address this gap in model specification, BAE Systems conducted a focused literature search for meso-level theoretical models that were both compatible with Flannery, in that the direction of causation within the models was identical to Flannery's, and addressed levels of interaction and analysis lower than those described by Flannery. In addition, Flannery's theory was bolstered by using literature that focused on the collapse of social complexity.

Literature emphasizing the meso level of analysis focused on issues of social composability and the institutionalization of societal functions into formal and informal

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[7] Experts on Iraqi political and military organization have noted that Saddam Hussein's Iraq had become increasingly managed and organized based on bonds of kinship and personal loyalties after operation Desert Storm in 1991 and the subsequent assassination attempts on Saddam Hussein (Baran 1998).

organizations, and the role of elites in motivating and directing collective action. One source of particular value was the work of Michael Mann, who examined the rise of the state and the elites that manage it through the formation and control of four different networks: informational, economic, military, and political (Mann 1986). Mann's work specified the relations between the types of power that reside within society, and that are effectively used by elites to achieve political objectives.

In addition to Mann, other work on opinion formation was used to examine the relationships between elites and to model the convergence or divergence of interests based on institutional and personal affiliations. By endowing elites with multiple identities, their strategies and actions occur within a social context, and the activation and deactivation of resident identities is both a determinant of behavior and an outcome of increases and decreases in social complexity (Lustick et al. 2004).

Finally, because Flannery's theory is primarily directed at a society's accumulation of social complexity, theories of societal collapse were also used to further refine and specify the model. The primary texts used to examine the issue of collapse were Joseph Tainter's *The Collapse of Complex Societies* (Tainter 1988), which specifically deals with sudden or short-term losses of social complexity, and Jared Diamond's *Collapse: How Societies Choose to Fail or Succeed* (Diamond 2005), which largely deals with environmental change and the effects of environmental destruction on polities. Both of these texts argue that social fragility can develop rapidly, and that the loss of social complexity can occur suddenly, perhaps within a single generation.

These additional texts are important because they link the process by which states form to the paths by which they fail. For example, Tainter argues that collapse can be regarded as the reversal of the process of state formation (Tainter 1988, page 38). Likewise, Diamond argues that collapse occurs as a result of failures in collective decision-making — in particular, the failure to anticipate problems, the lack of awareness that problems have arrived, and conflicts of interest within the group's membership or between elites and society (Diamond 2005, pages 419–440). Linking state formation to government institutional design and behavior and decision-making patterns and priorities — the attributes and capabilities with which states confront threats to their cohesion — has been a long-standing tradition within social science research and remains a valuable and fruitful research area (Machiavelli 1981; Ayoob 1995; Smith 2005b).

Given the advantages of Flannery's theory, BAE Systems determined that it was far better to bolster it with supporting meso-level models, rather than find an alternative theory, because of the fruitfulness and novelty of Flannery's ideas. The shortcomings of Flannery's original work (i.e., theoretical underspecification) were addressed by selecting theories from anthropology and other social sciences to create a more complete view of the behavior of the system at lower levels of analysis while remaining true to Flannery's macro-level emphasis on social complexity.

To create these various levels of hierarchy, i.e. macro and meso, it was necessary to use the multi-agent modeling methodology for social structure to emerge and reflect the dynamics of increased complexity. Thus, starting from the micro level (i.e., the level of agents and their ability to exploit environmental resources), the effort allowed for observing the formation of social structure (meso-level) in the form of societal networks (ideology, economic,

military/coercive, and political) that collectively illustrated complex relationships analysts could associate with an organizational form such as a "state." An illustration of this relationship is shown in Figure 1.

Of even greater interest to the authors was illustrating conditions that suggested societal fragility. Involved in this case was the emergence of networks of elites capable of reducing the "authority" of the government, as measured by nongovernmental cliques with access to environmental resources. Consistent with Flannery's theory, one could interpret these cliques as being equivalent to emerging chiefdoms that challenge or reduce the "power" of formal governance networks. It is assumed that at some critical yet undetermined threshold, the governmental networks become weak enough that the nongovernmental cliques could substantially reduce perceived legitimacy. The reduction could be in the form of governmental collapse or the emergence of the cliques as de facto, and necessary, societal institutions.

In addition to providing an elegant means of instantiating the respecification of Flannery's theory, the ABM methodology was selected for instantiating SOET, for several additional reasons. First and foremost, ABMs are particularly attractive for modeling emergent properties and situations where activities at one level of analysis produce behaviors and structures at higher levels of analysis that cannot be predicted based on the average properties of the lower level components (Axelrod 1997; Resnick 2000). Thus, in the case of SOET, the ABM is based on modeling the arrangement of self-interested elites into organizations that induce transitions into and out of differing governing structures. Through this process of micro-level interactions, society can be viewed as an emergent property that results from the disaggregated, uncoordinated actions of elites; and the state is considered to be structures in which powerful individuals work through existing institutions and network structures remain stable as individuals move through the power structure.

The second advantage of an ABM is that it allows for the instantiation of numerous social theories of behavior, many of which have not been formally represented or tested due to the

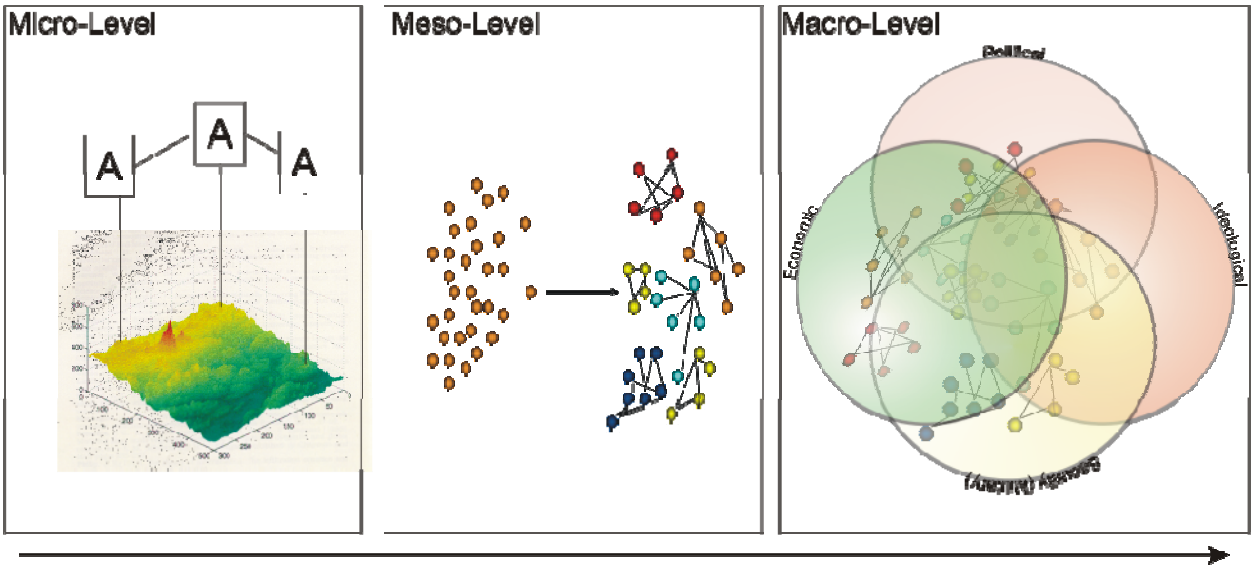

FIGURE 1 Illustration of multi-level modeling formalism

limitations of older modeling formalisms. Computational methods in general and ABMs in particular allow for the algorithmic representation of social behaviors that through recursion and mutation generate social phenomena (Axtell 2000; Epstein, forthcoming). Thus, an ABM serves as a methodological innovation that allows for the development, instantiation, and testing of a social body of theory that is grounded in social interactions, rather than inferencing based on statistical regularities, extrapolations of time-series data, or mathematical simplifications that assume closed-form solutions to social problems.

By instantiating SOET as an ABM a new form of knowledge can be created. Because ABMs provide insights into the dynamics of systems based on individual-level acts of agency, as opposed to stocks and flows of large aggregates, model users can gain a better understanding of when a system's behavior is likely to change as a result of individual and collective decision-making. This is important because statistical models generally extrapolate based on known data, implicitly asserting that the future will resemble the past and that the causal mechanisms within the society are stable. Therefore, while statistical methods can interpret empirical data to show a society's present condition, they cannot predict that society's trajectory should the underlying structure change as a result of changing dynamics — an ABM provides an insight into these dynamics.

A third advantage of the ABM formalism is its ability to support scenario planning, hypothesis testing, and other forms of exploratory analysis and credible model exploitation (Bankes 1993; Lempert et al. 2003; Saunders-Newton 2006). Although the PCAS "sapling" emphasized the modeling of a small number of nations, the longer term intent of the DARPA effort was concerned with developing an ability to explore scenarios and examine potential futures that result from alternative policy choices. ABM provides an attractive, dynamic simulation environment where alternative data sets, behavioral rules, agent or system attributes, etc., can be explored. Linking these simulation "hooks" to policy levers allows for the systematic exploration of outcome spaces based on potential policy options. The ABM formalism allows analysts and policy-makers to reach beyond today's information and explore alternative futures, identifying paths to desirable, stable structures and the indicators of troublesome outcomes.

Brief Technical Description of SOET

The actual realization of the SOET formalism required the development of a software environment inclusive of agents (individual and organizational), their interactions between each other and various resource landscapes. To that end, the BAE Systems team represented "nation-state" dynamics in terms of each agent's ability to transform resources into goods that would enable it to pursue various goals. The action of creating products comes at a cost to the agent, and often require negotiating with other agents. The transactions between agents themselves and the environment are represented — and managed — by the connections. The underlying dynamics of SOET are further illustrated in Figure 2.

The initial model exploited the simulation engine of a Java-based ABM development environment called Repast.[8] The Java agents are unique to the BAE Systems approach. Future

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8 Repast is the acronym for the Recursive Porous Agent Simulation Toolkit. It is an open-source software environment that can be downloaded at http://repast.sourceforge.net.

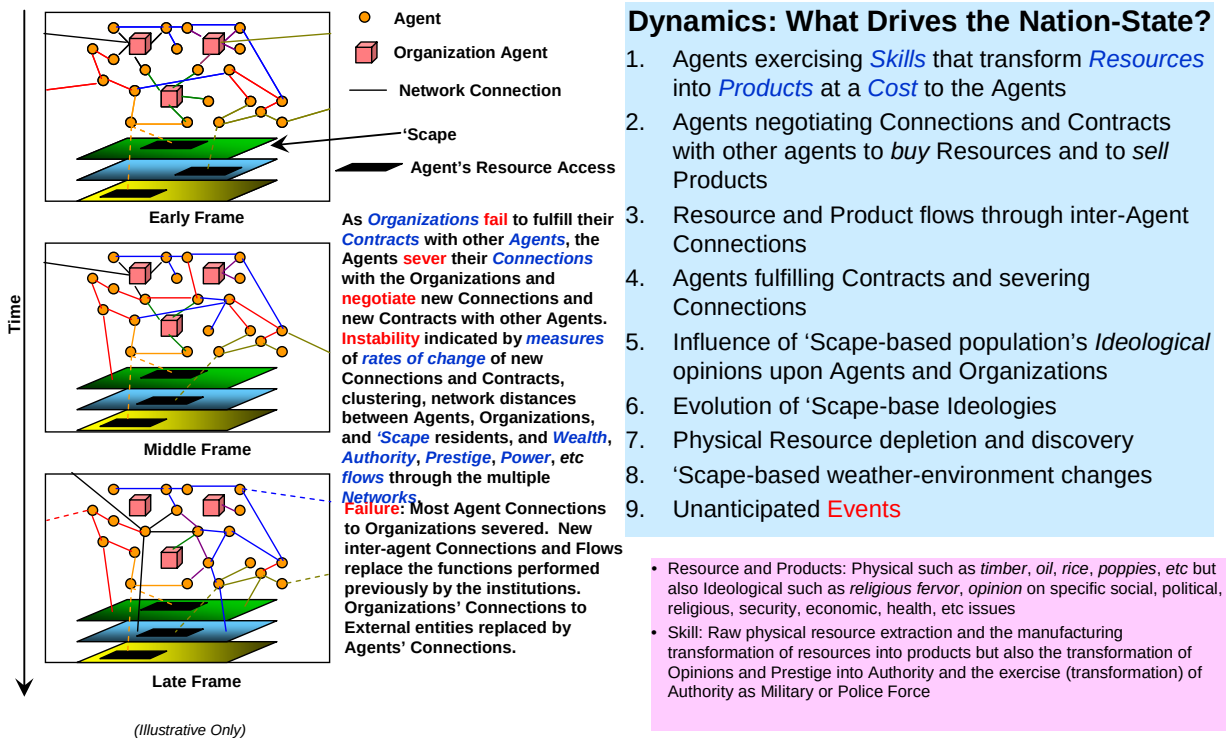

FIGURE 2 Illustration of dynamics associated with nation-state

instantiations of this model will likely make use of a custom-crafted ABM development environment that will allow for more efficient development efforts inclusive of an ability to easily edit nation-state or societal configurations, as well as multi-processor instantiations.

CONCLUSIONS

Compared to traditional methodological approaches of modeling and interpreting societal fragility and state failure, the SOET approach was extremely novel. By exploiting the power of multi-agent simulation and revisiting and reconsidering some of the major theories of cultural evolution, the authors found a means of examining the dynamics of state formation as it relates to fragility and possible state dissolution. This evolutionary approach differed greatly from the statistical approaches that tend to characterize this area of study. It is the opinion of the authors that it is difficult to understand why a state fails without actively considering how it came to be fragile. Statistical models do not typically allow for the easy representation and consideration of such concepts.

The challenge in this case is that theories for interpreting the evolution of societies over time are not well specified for instantiation as agent-based models. Flannery's theory, as an example, reflects systems-level thinking, and as such suggests the use of a system dynamics approach. However, the "stock, flow, feedback" metaphor of this methodological approach is not an appropriate means for considering both state formation and evolution. Moreover, Flannery's theory does not speak to the underlying dynamics that give rise to choices by the agents who comprise the social forms he delineates, i.e. bands, tribes, chiefdoms, and states. Thus, even if it

were possible to represent these notions in the most likely methodological approach, the instantiation of agency is not aided by Flannery's work.

Thus, efforts to convert many of the intuitively appealing theories of social outcomes and dynamics will benefit greatly from a more systematic approach for representing the agency that is implicit in the theoretical frameworks posited by many social thinkers. This will aid researchers, analysts, and decision-makers greatly in exploiting the rich corpus of social thought that has been created over recorded time.

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